THE PERFORMANCES OF TWO WILD AND TWO HYBRID STRAINS OF BROOK TROUT PLANTED IN AN INFERTILE, ACIDIC LAKE

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ABSTRACT

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Survival, growth and food habits of four strains of brook trout (*Salvelinus fontinalis*) planted simultaneously as fall fingerlings in Crystal Lake, Algonquin Park, Ontario, were remarkably similar. Crystal Lake is acidic (pH ≈5.3), poorly buffered (alkalinity 0.18 mg/litre as $CaCO_3$), and relatively infertile (total dissolved solids 17 mg/litre). All four strains grew rapidly, reaching 800 g in weight at age 3 and 1100-1200 g at age 4. Survival over the two years following planting ranged from 7.7-18.8%.

The 7705 fall fingerlings, which collectively weighed 26 kg at planting, were reduced in two years to an estimated 950 fish weighing 447 kg - a standing stock of 12.3 kg/ha. The reduction in numbers was due chiefly to natural mortality, although some illegal angling was reported for this sanctuary lake.

Keywords: brook trout, strain, acidification, survival, standing stock, Algonquin Park

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INTRODUCTION

Lakes situated on the Precambrian Shield in south-central Ontario are poorly buffered, and their fish populations are endangered by the continuing deposition of acid rain (Dillon et al. 1978). Many of these lakes support natural populations of brook trout *(Salvelinus fontinalis)*, but a substantial number of the smaller lakes, which otherwise provide excellent habitat for brook trout, do not possess suitable spawning areas for this species. Although such poorly buffered lakes have been planted regularly with hatchery-reared brook trout, little is known of their productive capacity. At the same time, little is known of the performances of the various strains of brook trout that could be utilized in acid lakes. In this study, we assess the performances of four strains of brook trout in acidic Crystal Lake, and we obtain a measure of the capacity of the lake to support planted brook trout. The study began with the planting of fall fingerlings in 1977, and continued with population studies from 1979 to 1982.

METHODS

The two wild brook trout strains (Lake Nipigon, Dickson Lake) and the two hybrid crosses (DICK × DOM (Dickson female × domestic male), DICK × NIP (Dickson female × Nipigon male)) have been described in an earlier study (Fraser 1981). The Nipigon strain fingerlings, however, were from eggs collected from Lake Nipigon stock that had been planted in Crystal Lake 3-4 years earlier. All four stocks were incubated and reared at Pembroke Hatchery, and appeared healthy and vigorous when planted as fall fingerlings by air-drop in Crystal Lake on October 6, 1977. Three to four days prior to planting, the fish were anesthetized with ethyl m-aminobenzoate methanesulfonate (MS222) and finclipped. Samples of fish were dip-netted from the rearing trough and fork lengths were measured. Mean weight was determined by counting the number of fish in a 1-kg lot.

Crystal Lake is located at 45°23'N and 78°29'W in Algonquin Park, Ontario, near its southern boundary. The lake is 36.4 ha in area, 15 m in maximum depth, and 4.3 m in mean depth. Its water is exceptionally clear (Secchi 9.1 m), acidic (pH =5.3), relatively infertile (TDS 17 mg/litre), and poorly buffered (total inflection point alkalinity, 0.18 mg/litre as $CaCO_3$). (Note: Preceding values are means, logarithmic for pH, of determinations made in July 1980 and July 1982.) The fish community consists of northern redbelly dace *(Phoxinus eos)*, fathead minnow *(Pimephales promelas)*, brook stickleback *(Culaea inconstans)* and small numbers of carryover brook trout from earlier plantings. Natural reproduction of brook trout does not occur. Crystal Lake was declared a sanctuary for research purposes in 1964, and it has been used as a holding area for brood stocks, mainly Lake Nipigon strain brook trout.

Follow-up studies on the planted strains began in September 1979 when 270 age 2+ brook trout were caught in trapnets, measured (fork length), tagged and released. The strains were identified by fin clip. The tag used was a Canadian version of the Swedish smolt tag, attached by a polyethylene filament (Saunders 1968). Brook trout were caught by angling and in gillnets in March 1980, and in gillnets set annually in June of 1980, 1981 and 1982. The gillnets, of monofilament nylon, were 16 m long and 1.8 m deep. The net gang consisted of three 16-m sections of 51-, 64-, and 76-mm mesh (stretched measure). Some 89- and 102-mm mesh nets were also fished in 1981 and 1982. Brook trout caught by angling or in gillnets were examined for fin clips and tags, measured, and weighed; sex and maturity were determined and stomach contents were preserved. Later, stomach contents were identified; the organisms were separated into taxonomic groups, and the volume of each group was measured to the nearest 0.1 ml by water displacement in a graduated cylinder. The coefficient of condition (K) was computed: $K = W \times 10^5/L^3$, where W is the weight in grams and L is the fork length in millimetres.

Adjusted Petersen population estimates (Chapman 1951) were calculated for each strain, and for the strains combined, using the tagged-untagged ratios noted in the 1980 March-June sampling. Confidence limits (95%) were determined from Clopper and Pearson's (1934) charts for binomial proportions.

RESULTS

SURVIVAL

In September 1979, two years after the four strains had been planted, 253 of the trout were caught, tagged and released. Percentage recoveries of the planted strains by the trapnets were small, ranging from 4.5% for the Dickson strain to 1.7% for the Nipigon strain (Table 1). Estimated numbers surviving to September 1979 ranged from 333 for the DICK × NIP hybrid to 154 for the Nipigon strain, with intermediate numbers surviving for the Dickson and DICK × DOM strains. Given the broad overlap in the confidence intervals associated with these estimates, it seems likely that only minor differences in survival existed among the four strains and 200-300 survivors of each contributed to the aggregate estimate.

Overall, an estimated 950 brook trout (12.3%) survived from planting at age 0+ to age 2+. The mean length of brook trout at age 2+ was 33.1 cm and, using a length-weight graph based on survival data of earlier plantings in Crystal Lake, a mean weight of 470 grams per fish is indicated. Multi-

Table 1. Estimated survival to age 2+ of four strains of brook trout planted as fall fingerlings in Crystal Lake.

	Nipigon	Dickson	Dickson × Domestic	Dickson × Nipigon	Strains combined
Fin clip	RV	Ad	LP	RP	
Number planted (Oct. 1977)	2000	1590	2340	1775	7705
Number tagged and released (Sept. 1979)[a]	34 (1.7)	72 (4.5)	96 (4.1)	51 (2.9)	253
Number of tagged/untagged caught (March, June 1980)[b]	4/17	10/19	12/22	4/27	30/85
Estimated population (Sept. 1979)	154	199	261	333	950
Confidence limits (95%)	79-680	133-400	181-480	159-1275	744-1405
Percent survival to Sept. 1979	7.7	12.5	11.2	18.8	12.3

[a] Percentage of number planted is in brackets.

[b] 44 by angling, 71 in gillnets.

Table 2. Mean fork length (centimetres) at various ages of four strains of brook trout planted in Crystal Lake. Numbers of fish are in parentheses.

Age	Nipigon	Dickson	Dickson × Domestic	Dickson × Nipigon
0+ (at planting, Oct. 1977)	6.8 (52)	6.3 (107)	7.3 (57)	6.3 (47)
2+ (Sept. 1979)	33.0 (32)	32.0 (72)	34.6 (96)	32.0 (47)
3 (Mar. 1980)	35.6 (13)	34.3 (18)	35.7 (19)	36.0 (16)
3 (June 1980)	40.2 (8)	37.9 (11)	39.5 (15)	40.4 (15)
4 (June 1981)	44.8 (4)	45.4 (9)	45.0 (6)	46.5 (7)
5 (June 1982)	44.8 (1)		46.7 (2)	45.8 (3)
5+ (Sept. 1982)	48.6 (1)		46.9 (2)	49.1 (1)

Table 3. Mean weights (grams) at various ages of four strains of brook trout planted in Crystal Lake. Numbers of fish are in parentheses.

Age	Nipigon	Dickson	Dickson × Domestic	Dickson × Nipigon
0+ (at planting, Oct. 1977)	3.6	2.5	4.2	2.8
3 (Mar. 1980)	499 (13)	470 (18)	504 (19)	523 (16)
3 (June 1980)	820 (8)	707 (11)	828 (15)	865 (15)
4 (June 1981)	1100 (4)	1233 (9)	1121 (6)	1271 (7)
5 (June 1982)	1150 (1)		1075 (2)	1167 (3)

plying the estimated mean weight by the estimated population of 950 fish indicates a standing stock of brook trout of 447 kg or 12.3 kg/ha. In addition, some survivors of a 1979 yearling planting of brook trout (LV clip) were also extant in the lake in September 1979. Twenty-one (LV) were caught along with the four earlier planted strains (combined total of 115). Applying this ratio to the estimated population of 950 age 2+ brook trout indicates some 173 age 1+ (LV) brook trout were also extant at the time of the estimate. These age 1+ fish would weigh about 150 g and constitute a standing stock of 26.0 kg, bringing the overall brook trout standing stock to 473 kg or 13.0 kg/ha.

GROWTH AND CONDITION

All four strains were small (6-7 cm) at time of planting, and all reached 32-34 cm in mean length at age 2+ in September 1979 (Table 2). The growth of all four strains continued to be remarkably similar over the following three years. The mean length of the Nipigon strain, which was 40.2, 44.8 and 44.8 cm at ages 3, 4 and 5, respectively, typifies the growth of the other strains. All strains but Dickson were caught as 5-year olds in the 1982 sampling, and it is likely that a few fish will reach age 6.

The large size attained by planted trout was due, in part, to continued growth through the winter. Fish tagged in September 1979 and recaptured in March 1980 had increased 2.6 cm in length (n = 15). Expectedly, spring growth rate was faster with the mean increment of tagged fish recaptured in June 1980 averaging 6.3 cm (n = 16). All strains increased 50-65% in weight during the 3-month period March 4 - June 4, 1980, when the fish had reached age 3 (Table 3). It is likely that much of the gain was made in the latter half of the period – after ice breakup on April 25, 1980. Overall, fall fingerlings, tiny at time of planting (2.5-4.2 g), reached 800 g at age 3 and 1100-1200 g at age 4 (Table 3). Growth apparently ceased after age 4.

All strains were in similar condition when first sampled in March 1980; K ranged from 1.14 to 1.10 (Table 4). Condition factor (K) increased rapidly during the following three months to reach the 1.23-1.35 range by June 1980. A year later, at age 4, K had decreased slightly from the age 3 values. At age 5, the small number of fish sampled indicated a further deterioration in condition.

MATURITY

Examination of the gonads of fish caught in March and June 1980 indicated that the majority of males and females of all four strains reached maturity in Crystal Lake by age 2+ (Table 5). Overall, 82% of males and 77% of females were mature at this age. A slightly higher percentage of the DICK × DOM hybrids had matured by age 2+, probably due to the influence of the domestic parent strain which normally matures at age 1+.

FOOD

The diet of adult brook trout (25-50 cm) in Crystal Lake varied with the season of the year (Fig. 1). Ephemeroptera (mainly *Hexagenia*) nymphs, Amphipoda (*Crangonyx gracilis*) and fish (mainly brook sticklebacks) were the chief food organisms noted in the stomachs of trout caught under the ice. In the spring, Diptera and Odonata replaced Ephemeroptera in the diet and a few larger food items (leeches, frogs, crayfish) were also noted. Since the present study was restricted to winter and spring sampling only, data from an earlier period (1970) have been used to describe the summer and autumn diets of brook trout (Fig. 1). In the summer of 1970, the diet consisted almost entirely of Ephemeroptera, Diptera and Hemiptera, while in the autumn following, Hemiptera (mainly Corixidae) dominated the diet.

The diets of the four brook trout strains were approximately similar, as demonstrated in Fig. 2, for the winter sample of 3-year old fish. Brook trout caught in the winter had fuller stomachs than those caught in other seasons, probably as a result of slower digestion rate in colder water. Fewer empty stomachs were noted

Table 4. Condition factor (K) at ages 3, 4, 5 of four strains of brook trout planted in Crystal Lake. Numbers of fish are in parentheses.

Age	Nipigon	Dickson	Dickson × Domestic	Dickson × Nipigon
3 (Mar. 4-5, 1980)	1.11 (13)	1.14 (18)	1.10 (19)	1.11 (16)
3 (June 4-5, 1980)	1.23 (8)	1.32 (11)	1.35 (15)	1.31 (15)
4 (June 16-17, 1981)	1.18 (4)	1.33 (9)	1.24 (6)	1.28 (7)
5 (June 15-16, 1982)	1.28 (1)		1.06 (2)	1.21 (3)

Table 5. Number of immature and mature brook trout of various strains caught at age 3 in March, June, 1980.

Strain	Male			Female		
	Immature	Mature	% Mature	Immature	Mature	% Mature
Nipigon	3	7	70	2	8	80
Dickson	2	14	88	4	9	69
DICK × DOM	1	9	90	3	19	86
DICK × NIP	3	11	79	5	12	71
Strains combined	9	41	82	14	48	77

in the winter sample.

Season	Mean volume (ml) of stomachs containing food	% empty stomachs
Spring	2.8	28
Summer	3.6	29
Autumn	4.5	14
Winter	11.0	11

Crystal Lake provides a variety of food organisms, and planted brook trout appear to be opportunistic feeders taking whatever organisms are abundant and available.

DISCUSSION

In its present state, Crystal Lake provides adequate habitat for planted brook trout. Although it is among the more acidic waters in the Algonquin Park area, its pH apparently was not low enough to bring out any differences in acid tolerance among the four planted strains if, indeed, any differences existed. Flick et al. (1982) report superior performance by the Temiscamie hybrid (brook trout) in field studies conducted in western slope Adirondack waters subject to more intense acidification, but caution that the differential regional results could not be explained by acidity factors alone.

The Crystal Lake findings are in agreement with the European Inland Fisheries Advisory Commission (1969) water quality criteria - "pH range of 5.0-6.0 is unlikely to be harmful to any species.....". More specifically for brook trout, our growth results support the conclusion of Smith (1978) that juvenile-adult brook trout exposed at or above pH 5.0 grow at a normal rate.

Although Crystal Lake is infertile and lacks any measurable buffering capacity, the four planted strains grew at similar and relatively rapid rates, utilizing a variety of food organisms that were available at various times of the year. The

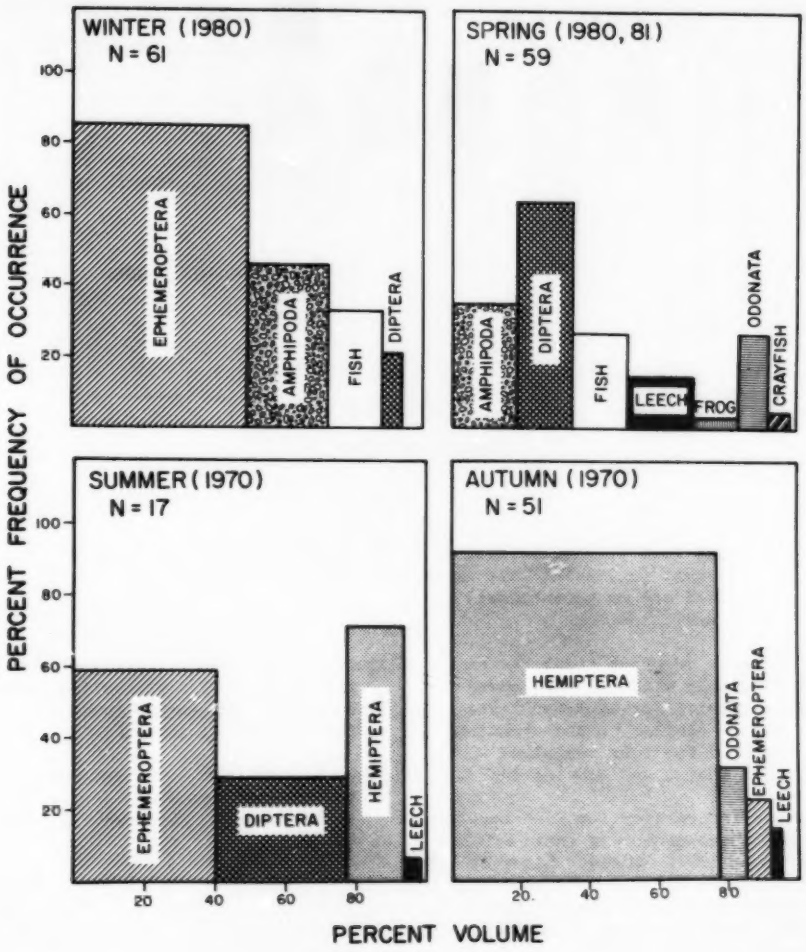

Figure 1. The food of brook trout (25-50 cm in length) caught in Crystal Lake in various seasons of the year. N = number of fish examined.

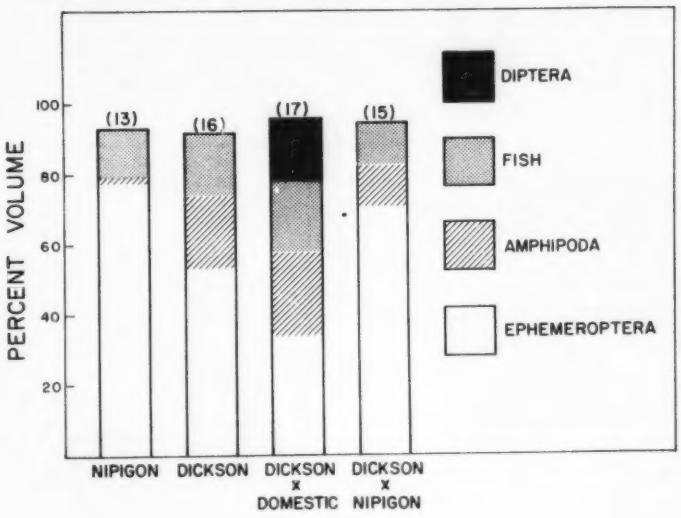

Figure 2. The food of four strains of brook trout (28-42 cm in length) caught in Crystal Lake in March, 1980. Numbers of fish examined are in parentheses.

standing stock of 12.3 kg/ha of brook trout reached by age 2 compares favorably with the mean standing stock of 4.6 kg/ha reported for 18 trout lakes by Carlander (1955), and is similar to the standing crops of 8-20 kg/ha reported for four reclaimed Adirondack Mountain lakes (Hatch and Webster 1961).

This paper provides information for fish managers responsible for the management of small acidic lakes located on the Precambrian Shield. Since the continuing deposition of acid rain on this area can be expected to eventually reduce the lakes' capability to support fish, this study may be useful as a baseline for future investigations.

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